INDOOR AIR QUALITY ASSESSMENT

Manomet Elementary School
70 Manomet Point Road
Plymouth, MA 02360

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Susan Merrifield, Health Director, Plymouth Department of Public Health (PDPH) and Arthur Montrond, Supervisor of Buildings and Grounds, Plymouth Public Schools (PPS), the Massachusetts Department of Public Health (MDPH)'s Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Manomet Elementary School (MES), 70 Manomet Point Road, Plymouth, Massachusetts. On January 14, 2005, a visit to conduct an indoor air quality assessment was made to this school by Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. During the assessment, Ms. Lee was accompanied by Steven Nelson, Assistant Director to Buildings and Grounds, PPS. A reported odor of an undetermined origin detected in room 4 prompted the request.

The MES is a single-story brick building constructed in 1952. An addition consisting of seven classrooms was built in 1962. A modular building consisting of six classrooms was added in the late 1980s. In 1999, another addition was constructed and the 1952 and 1962 wings were renovated. The school consists of classrooms, offices, a gymnasium, an art room, a library, a cafeteria, a music room and a computer lab. Windows throughout the building are openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 350 kindergarten through fifth grade students and approximately 50 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate air exchange. It is important to note that some areas were empty or sparsely populated at the time of the assessment, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with increased occupancy.

Fresh air in classrooms is mechanically provided by unit ventilator (univent) systems. A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were deactivated in many classrooms at the time of the assessment. Obstructions to airflow, such as desks and other items located on or in front of univents, were also observed despite signs advising against such practices (Pictures 1 and 2). To function as designed, univents must be allowed to operate and remain free of obstructions.

Exhaust ventilation is provided by ceiling-mounted or closet vents (Pictures 3 and 4), which are ducted to motorized fan units on the roof. For rooms with closet exhausts, classroom air is drawn through a space beneath the closet door and into the closet (Picture 5). The exhaust vents located in the upper portions of the coat closets exhaust air. However, closet exhaust vents are prone to obstruction by items placed in front of floor level openings and/or on shelves below the vent. In addition, several ceiling-mounted vents are located near hallway doors (Picture 6). When classroom doors are open, exhaust vents for these rooms will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants. As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

Mechanical ventilation for portable classrooms is provided by air handling units (AHUs). Fresh air is distributed to portable classrooms via ductwork connected to slotted air diffusers located between ceiling tiles (Picture 7). Return air is drawn into slotted ceiling vents and ducted back to the AHUs.

To maximize air exchange, the MDPH recommends that ventilation equipment operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last servicing and balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

The temperature measurements ranged from 69^{o} F to 74^{o} F, which were within or very close to the lower end of the MDPH recommended comfort guidelines (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity measurements ranged from 43 to 63 percent, which were within or slightly above the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

All classrooms in the portable wing had water-damaged ceiling tiles (Picture 8). Water-damaged ceiling tiles can provide a source for mold growth and should be replaced after a water leak is discovered and repaired. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.

Wallpaper-like material above windows in the portable classrooms was observed to be loose (Picture 9). This is an indication that water is penetrating from the exterior and moistening the wallpaper-like material. As with water-damaged ceiling tiles, water damaged porous materials can be a source for mold growth. In addition, wallpaper layers can trap other materials that can be a source for mold growth. Water-damaged wallpaper should be removed to prevent potential mold growth in/on building materials. Materials behind the wallpaper should also be examined.

Spaces between the sink countertop and backsplash were seen in several areas (Picture 10). Improper drainage or sink overflow can lead to water penetration into the countertop, cabinet interior and areas behind cabinets. If these materials become wet repeatedly they can provide a medium for mold growth.

The American Conference of Governmental Industrial Hygienists (ACGIH) and United States Environmental Protection Agency (US EPA) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If items are not dried within this time frame, mold growth may occur. The application of a mildewcide to mold colonized porous materials is not recommended.

A number of other conditions observed along the building exterior may be conducive to water penetration through the building envelope. Breaches were noted in and around the building and its windows. A rubber gasket for a classroom window was also failing (Picture 11). These breaches can serve as points for water entry into the building. Continued freezing and thawing of water during winter months will serve only to further damage the foundation. In addition, breaches can serve as points of entry or shelter for pests.

Plants were noted in several classrooms. Plants should be properly maintained and equipped with drip pans. Some plants were placed near ventilation sources (Picture 12). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be located away from univent air diffusers to prevent the aerosolization of dirt, pollen or mold.

Odor Investigation of Classroom 4

Classroom 4 is a first floor room located at the front of the 1952 building. The eastern wall of the classroom faces the MES's pick-up/drop-off area. The northern wall is opposite rooms 6 and 7, which are located in the 1962 school wing. A grass patch separates the 1952 and

1962 wings. Windows are located on the northern and eastern walls; the classroom univent is also located on the northern wall.

According to Mr. Nelson, the odor, which is described as musty and moldy, has persisted since October 2004. Classroom occupants have been relocated several times while maintenance staff have tried to determine the origin of the odor. The PPS's maintenance department has attempted to rid the room of the odor through a combination of activities. When the odor was first detected, the occupant of this classroom removed and cleaned/discarded items; the maintenance staff also examined and cleaned furniture, fixtures, pipes, etc. Although the odor appeared to dissipate after the cleaning, the odor returned within a week. According to Mr. Nelson, it is likely that the cleaning agents temporarily masked the odors.

Maintenance staff have continued to work towards resolving the odor issue. Cabinets were removed and cleaned. Walls, crawlspaces and the ceiling plenum were opened for inspection of mold and/or rodents. Window ledges were removed and the space between the wall and furniture was cleaned (Picture 13). Maintenance staff also performed general univent cleaning, but did *not* fully dismantle and clean the entire interior and exterior of the univent. In addition, an inspection of the building exterior was conducted. While discussing the history of activities conducted in classroom 4, Mr. Nelson indicated that other areas of the school have experienced problems with feral cats.

Mr. Nelson reported extensive investigation efforts were made. PPS staff examined the room when the univent is activated and deactivated. According to Mr. Nelson, the odor is strong in the morning, especially if the univent has not operated for some time (e.g., over the weekend). When the univent is operating, the odors become stronger as they accumulate in the southeast corner of the room. Throughout the course of these activities, the PPS has worked with PDPH. Despite these efforts, the odor problem persisted.

When MDPH staff first examined classroom 4, the univent was not activated. The odor was pungent, akin more to skunk or urine rather than mold. MDPH staff conducted a cursory investigation, activated the univent and exited the room. MDPH staff later returned to the classroom to conduct a complete investigation of classroom 4 and examine all fixtures in the room, including areas where PPS staff had conducted cleaning activities. It did not appear that sources for mold growth were present in the classroom at the time of the assessment.

As discussed, the univent was activated during the course of the day. MDPH staff confirmed that the odor was strongest in the southeastern corner of the room. The strength of odor concentrated in this corner coupled with previous problems experienced with feral cats and type of univent cleaning conducted suggests that the odors in classroom 4 may be attributed to feral cats urinating in/near the classroom univent. Since the univent was never fully dismantled and cleaned, urine may still be present in the univent. Considering the number of flat, non-continuous surfaces present within the univent, urine may have spread within the univent and into seams. Although flat surfaces may have been wiped when the univent was cleaned, seams may not have been cleaned. Remnants of the byproduct remaining in the univent may have resulted in odor generation. Air passing over byproduct remains would tend to aerosolize and magnify odors.

As discussed, when the univent is activated, the odor tends to be stronger against the south wall. This condition may be attributed to the univent location; the univent is located on the opposite wall. When fresh air is distributed though diffusers at the top of the univent, fans within the univent push air outwards to ensure fresh air is distributed throughout the classroom.

In the case of classroom 4, air moves from the univent towards the southeast corner wall. Once fresh air meets the wall, it moves downwards, allowing air to linger. As a result, odors tend to concentrate in this area. A full cleaning of the univent, including disassembly and flushing of the entire unit's interior and exterior should serve to reduce/eliminate the odor.

Other IAQ Evaluations

Indoor air quality can also be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring fresh air introduced by HVAC systems

(ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND (Table 1).

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, the US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 26 μg/m^3 (Table 1). PM2.5 levels measured indoors were in a range of 1 to 24 μg/m^3 (Table 1), which were below background as well as the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can also generate particulates during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no TVOC levels measured, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

A number of cleaning agents were also observed in classrooms (Picture 14). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Also of concern are unlabelled bottles and containers. Products should be kept in their original containers and be clearly labeled for identification purposes, especially in the event of an emergency.

Several other conditions that can affect indoor air quality were noted during the assessment. Accumulated chalk dust was noted in chalk trays of some classrooms. Chalk dust is a fine particulate that can easily become aerosolized. Once aerosolized, chalk dust can become irritating to eyes and the respiratory system. A number of exhaust/return vents were noted with accumulated dust (Pictures 3 and 4). If exhaust vents are not functioning, backdrafting can occur. This can result in re-aerosolization of accumulated dust particles.

In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks (Picture 15). The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Food containers were observed as being used for storage. Reuse of food containers in this manner can serve to attract pests, since food residue is likely present in containers despite cleaning efforts. To prevent pests, such reuse of food containers should be avoided.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 16). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause TVOCs to off-gas. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998). Consider replacing tennis balls with alternative glides (Picture 17).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Ensure univent in classroom 4 is dismantled and cleaned thoroughly. Ensure seams within the unit are also cleaned and disinfected.
2. Consider consulting an animal control firm to determine the most appropriate method in dealing with feral cats.
3. Examine each univent for function. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
4. Examine exhaust vents for function and make repairs as necessary.
5. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.

6. Remove all obstructions from univents and exhaust vents to facilitate airflow. Close classroom doors to improve air exchange.
7. Remove debris and dust accumulated on ventilation grilles.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Identify and repair sources of water leaks. Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.
10. Examine and repair rubber window gaskets to prevent water intrusion.
11. Seal seams between sink countertops and backsplashes to prevent water damage.
12. Examine plant water catch basins for mold growth. Disinfect water catch basins if necessary. Remove plants from in close proximity to ventilation sources.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.

15. Clean chalkboard/dry erase marker trays regularly to prevent the build-up of excessive chalk dust and particulates.
16. Store cleaning products properly and out of reach of students. Ensure bottles are properly labeled in the case of emergency.
17. Refrain from using food containers as materials for projects.
18. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means for maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
19. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

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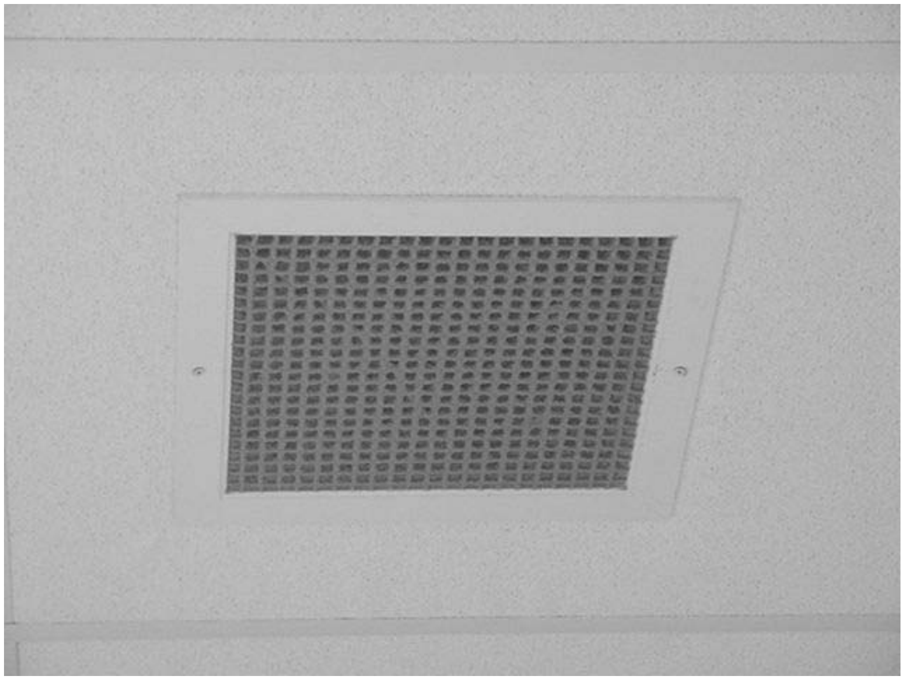
Picture 1

Univent located between desk and easel

Picture 2

Sign advising against placing materials on univent

Picture 3



Ceiling exhaust vent, note dust

Picture 4

Closet exhaust vent, note dust occluding vent and materials stored below vent

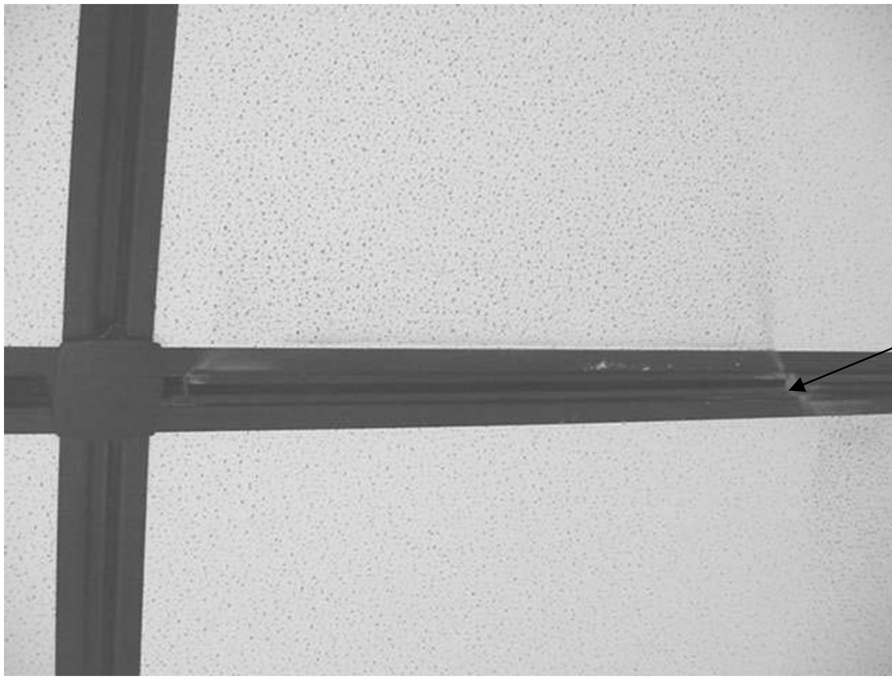
Picture 5

Undercut closet door

Picture 6

Ceiling vent located above door

Picture 7



Slotted air diffuser

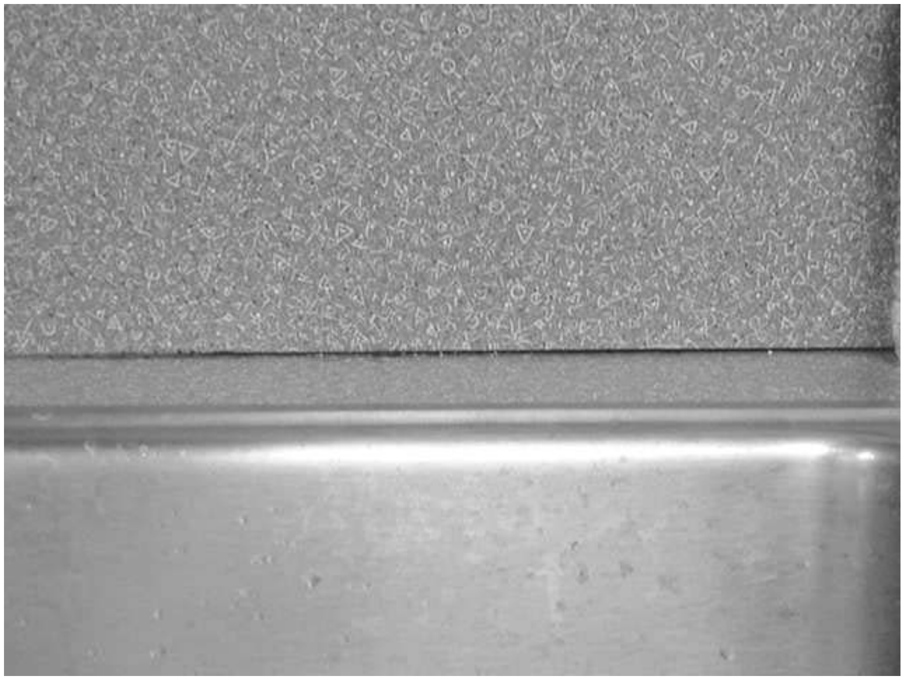
Picture 8

Water-damaged ceiling tiles

Picture 9

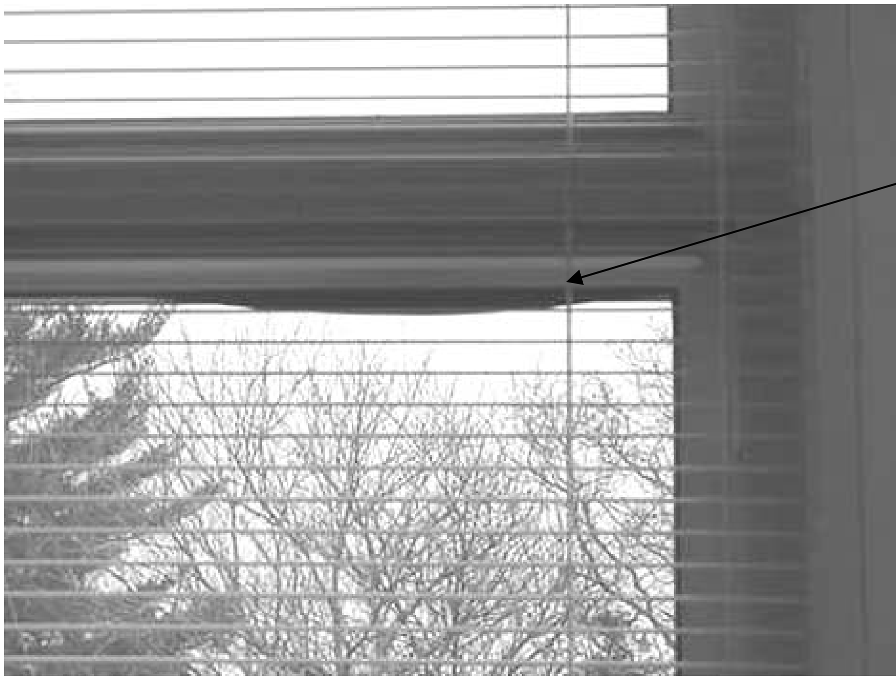
Water-damaged porous material

Picture 10



Space between sink countertop and backsplash

Picture 11



Failing rubber gasket in window

Picture 12

Plants near univent, note dust on top of univent

Picture 13

Ledge and grill that were removed

Wall and heating spaces cleaned during PPS investigation

Picture 14

Cleaning products

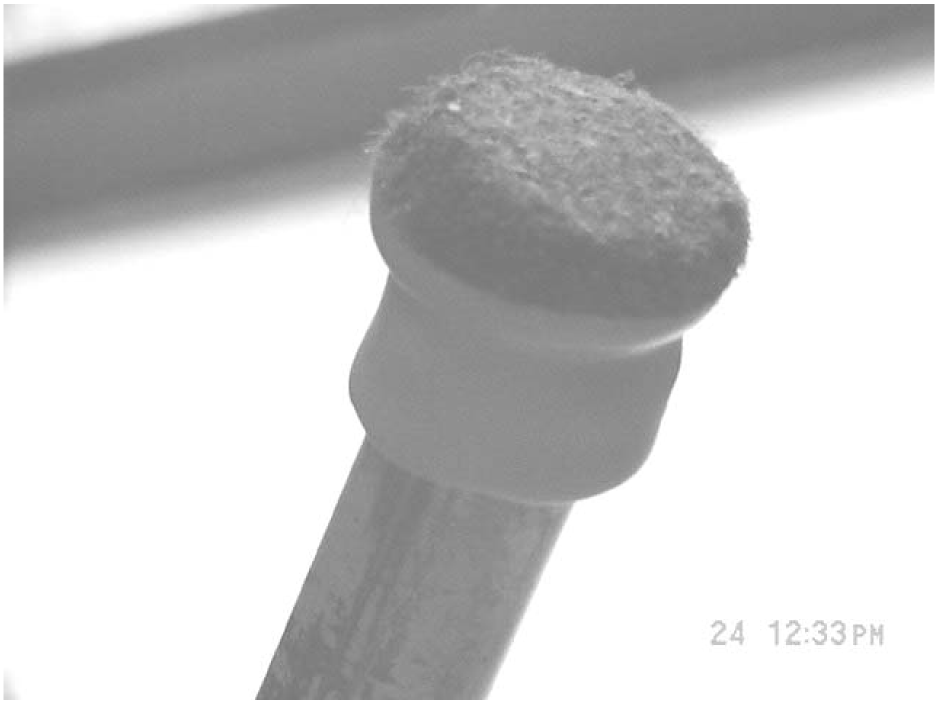
Picture 15

Storage of items

Picture 16

Tennis balls on chair legs

Picture 17



Alternative 'glides' for chair legs

Manomet Elementary School **Indoor Air Results**

70 Manomet Point Rd, Plymouth, MA 02360 **Table 1** **January 14, 2005**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		34	85	347	ND	ND	26				Overcast, drizzle, slight wind.
Art Room	0	71	57	418	ND	ND	8	Y # open: 0 # total: 5	Y univent	Y ceiling	Hallway DO, breach sink/counter, DEM, items, plants.
cafeteria	130	70	52	558	ND	ND	2	N	Y wall	Y wall	Hallway DO
conference room	0	71	53	450	ND	ND	2	N	N	Y ceiling	Inter-room DO, DEM.
gymnasium	0	71	53	347	ND	ND	6	N	Y ceiling	Y wall	
health	1	71	50	503	ND	ND	4	Y # open: 0 # total: 2	N	N	Hallway DO

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Manomet Elementary School | **Indoor Air Results**

70 Manomet Point Rd, Plymouth, MA 02360 | **January 14, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Learning Center A	0	71	51	427	ND	ND	7	Y # open: 0 # total: 2	Y univent	Y ceiling location	Hallway DO, DEM.
Learning Center B	6	71	57	476	ND	ND	10	N	Y univent	Y ceiling location	DEM, items.
library	23	71	60	396	ND	ND	16	Y # open: 7 # total: 12	Y univent	Y ceiling	Hallway DO, plants.
library office	0	74	57	430	ND	ND	16	Y # open: 1 # total: 2	Y ceiling	Y ceiling	Hallway DO, cleaners, items.
main office	3	71	48	456	ND	ND	2	Y # open: 1 # total: 4	Y ceiling	Y ceiling	Hallway DO

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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Manomet Elementary School **Indoor Air Results**

70 Manomet Point Rd, Plymouth, MA 02360 **January 14, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
music	0	71	61	475	ND	ND	12	Y # open: 0 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM, plants.
Principal's office	1	71	52	451	ND	ND	3	Y # open: 0 # total: 2	Y ceiling	Y ceiling	
Testing	0	72	63	524	ND	ND	18	N	Y ceiling	Y ceiling	Hallway DO, DEM.
1	0	72	62	520	ND	ND	16	Y # open: 0 # total: 10	Y univent	Y closet items dust/debris	Hallway DO, breach sink/ c ounter, damaged/missing window caulking/gasket.
2	19	71	63	642	ND	ND	17	Y # open: 0 # total: 10	Y univent	Y closet dust/debris	Hallway DO,

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BD = backdraft
CD = chalk dust
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CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
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									Supply	Exhaust	
3	33	72	61	647	ND	ND	24	Y # open: 0 # total: 7	Y univent	Y closet items dust/debris	Hallway DO, CD, DEM, cleaners, items, FC re-use, plants.
4	0	70	46	361	ND	ND	1	Y # open: 0 # total: 6	Y univent	Y closet	Morning: univent deactivated, slight odor, reactivated UV; Afternoon: univent activated, stronger more pungent odor.
5	20	72	62	707	ND	ND	10	Y # open: 0 # total: 6	Y univent dust/debris	Y closet dust/debris	CD.
6	21	71	60	654	ND	ND	13	Y # open: 0 # total: 6	Y univent items dust/debris	Y closet dust/debris	DEM, items, food use/storage

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									Supply	Exhaust	
7	0	71	61	490	ND	ND	11	Y # open: 0 # total: 6	Y univent items dust/debris	Y closet dust/debris	DEM, items, food use/storage
8	21	74	62	749	ND	ND	13	Y # open: 0 # total: 6	Y univent plant(s)	Y closet dust/debris	DEM, items.
9	1	74	58	447	ND	ND	8	Y # open: 2 # total: 6	Y univent	Y closet dust/debris	Hallway DO, CD, DEM, TB.
10	0	71	58	458	ND	ND	10	Y # open: 0 # total: 6	Y univent (off)	Y closet	Hallway DO, DEM, items, 1 (of 2) univents off.
12	15	71	49	449	ND	ND	1	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #MT/AT : 2, CD, DEM.

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13	13	69	47	537	ND	ND	2	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, CD, DEM, items, plants.
14	15	71	50	490	ND	ND	1	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #MT/AT : 2, DEM, PC, items.
15	0	70	49	515	ND	ND	1	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 2.
16	16	71	49	479	ND	ND	4	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 3, WD-GW, CD, DEM, plants.
17	18	69	43	497	ND	ND	1	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 2, #MT/AT : 1, CD, DEM.

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